The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A position measuring device usable for measuring a relative position between the position measuring device and a target member, the position measuring device comprising:

an array detector;

an optical path array element comprising a plurality of optical path elements; and

an angular filter portion that selectively transmits light rays from the optical path array element that are aligned along an operable direction,

wherein:

the position measuring device is positionable to provide an image on the array detector that corresponds to at least a portion of the target member, the image arising from the transmitted light rays; and

the image on the array detector is usable to determine at least one measurement value that corresponds to at least one degree of freedom of the relative position between the position measuring device and the target member.

2. The position measuring device of Claim 1, wherein:

the target member includes at least one respective target feature;

the at least one respective target feature gives rise to a corresponding respective image feature in the image on the array detector; and

the size of a corresponding respective image feature on the array detector is usable to determine an absolute measurement value for the corresponding respective target feature, the absolute measurement value corresponding to a translational degree of freedom along an axis that extends along a direction of separation between the position measuring device and the target member.

3. The position measuring device of Claim 2, wherein:

the at least one respective target feature comprises at least three respective target features that give rise to corresponding respective image features;

the at least one measurement value comprises three measurement values corresponding to three translational degrees of freedom of the relative position between the measuring device and each of the at least three respective target features; and

the position measuring device is usable for measuring a six degree of freedom relative position between the position measuring device and the target member.

4. The position measuring device of Claim 2, wherein the respective target feature is a target point, the respective image feature on the array detector comprises a ring-shaped image feature, and a nominal center location of the ring-shaped image feature on the array detector is usable to determine a relative displacement corresponding to two translational degrees of freedom along two mutually transverse axes that extend along a plane that is approximately normal to the direction of separation between the position measuring device and the target member.

5. The position measuring device of Claim 4, wherein:

the ring-shaped image feature comprises one of an ellipse and a circle;

a function that is one of an ellipse and a circle is fitted to the ring-shaped image feature;

the center location of the function is usable to determine the relative displacement corresponding to the two translational degrees of freedom along the two mutually transverse axes; and

a radial dimension of the function is usable to determine the absolute measurement value corresponding to a translational degree of freedom along the axis that extends along a direction of separation between the position measuring device and the target member.

6. The position measuring device of Claim 4, wherein:

the ring-shaped image feature comprises one of an ellipse and a circle;

the ring-shaped image feature has respective radial intensity profiles comprising the intensity values of respective sets of image pixels of the ring-shaped image feature lying along respective radial directions extending from a nominal center of the ring shaped feature;

a function that is one of an ellipse and a circle is fitted to a set of respective peaks determined for a set of respective radial intensity profiles;

the center location of the function is usable to determine the relative displacement corresponding to the two translational degrees of freedom along the two mutually transverse axes; and

a radial dimension of the function is usable to determine the absolute measurement value corresponding to a translational degree of freedom along the axis that extends along a direction of separation between the position measuring device and the target member.

7. The position measuring device of Claim 1, wherein the position measuring device further comprises a light source.

8. The position measuring device of Claim 7, wherein the light source is positioned to illuminate the target member through the optical path array element.

9. The position measuring device of Claim 1, wherein the angular filter portion is configured such that it selectively transmits only light rays that are approximately parallel to an optical axis of the angular filter portion and the optical axis is arranged along a direction that is one of a) a direction approximately normal to a reference plane that is parallel to a nominal plane of the optical path array element, and b) a direction that is angled relative to a direction that is normal to a reference plane that is parallel to a nominal plane of the optical path array element.

10. The position measuring device of Claim 9, wherein:

the optical axis of the angular filter portion is arranged along a direction that is approximately normal to the reference plane;

light rays from the optical path array element are refracted at a refracting surface that is inclined at an angle relative to the reference plane such that the light rays that are approximately parallel to the optical axis comprise light rays that are refracted at the refracting surface; and

the refracting surface comprises one of a) a surface of a prism element that receives the output image light, and b) a surface provided by a set of optical path

elements that comprise a set of optical fibers, the surface formed by the angled ends of the set of optical fibers.

11. The position measuring device of Claim 10, wherein:

the position measuring device further comprises a light source and a beam splitter;

the angular filter portion comprises a first lens arranged to receive the light rays that are refracted at the refracting surface and an aperture arranged at a focal plane where the light rays from the first lens are nominally focused;

the beam splitter is arranged along the optical axis between the first lens and the aperture such that the light rays from the first lens pass through the beam splitter before being nominally focused at the focal plane; and

the light source is arranged relative to the beam splitter such that illumination from the light source is deflected by the beam splitter to pass through the first lens and the optical path array element to illuminate the target member.

12. The position measuring device of Claim 9, wherein:

the angular filter portion comprises one of a) a first lens arranged along the optical axis to receive the light rays from the optical path array element and an aperture arranged along the optical axis at a focal plane where light rays from the first lens that are nominally parallel when entering the first lens are nominally focused, and b) a collimator array of long, narrow, tube-like structures that have parallel axes and that provide a small acceptance angle for input light rays.

13. The position measuring device of Claim 12, wherein the angular filter portion comprises a second lens having a focal distance F, and the second lens is located along the optical axis at the distance F from the aperture, between the aperture and the array detector.

14. The position measuring device of Claim 1, wherein:

the target member includes at least two respective target features;

the at least two respective target features give rise to corresponding respective image features in the image on the array detector; and

when a separation between the position sensing device and the target member is increased, the size of each of the respective image features increases on the array

detector, but a spacing between respective nominal centers of the respective image features does not increase on the array detector.

15. The position measuring device of Claim 1, wherein the target member comprises a two-dimensionally periodic array of target features that effectively comprise point features.

16. The position measuring device of Claim 1, wherein the optical path array element comprises an optical fiber bundle comprising parallel optical fibers, the plurality of optical path elements comprise a plurality of the parallel optical fibers, and the optical fiber bundle is configured such that input light rays from the target member are input through a planar face of the optical fiber bundle, the planar face comprising coplanar ends of the plurality of parallel optical fibers.

17. The position measuring device of Claim 16, wherein the parallel optical fibers are nominally cylindrical.

18. The position measuring device of Claim 17, wherein the parallel optical fibers have a diameter of at least 3μm and at most 80μm.

19. The position measuring device of Claim 1, wherein:

the optical path array element comprises a two-dimensional array of coplanar lenses;

the plurality of optical path elements comprise a plurality of the lenses; and

the array of coplanar lenses is arranged such that input light rays from the target member are input to the plurality of lenses and deflected by the plurality of lenses, to provide the light rays that are selectively transmitted by the angular filter portion.

20. The position measuring device of Claim 19, wherein an array pitch along at least one direction of the two-dimensional array is at least 3μm and at most 150μm.

21. The position measuring device of Claim 19, wherein the lenses are located on a side of the optical path array element that is oriented towards the target member, and the angular filter portion selectively transmits light rays from the optical path array

element that are deflected along a direction that is approximately normal to a nominal plane of the coplanar lenses.

22. The position measuring device of Claim 19, wherein each optical path element comprise one of: a) a refractive axicon-type lens, b) a refractive faceted pyramidal-type lens having at least 3 facets, c) a diffractive optical element that deflects light rays approximately like a refractive axicon-type lens, and d) a diffractive optical element that deflects light rays approximately like a refractive faceted pyramidal-type lens having at least 3 facets.

23. The position measuring device of Claim 22, wherein each optical path element comprises one of: a) a refractive axicon-type lens, and b) a refractive faceted pyramidal-type lens having at least 3 facets, and each optical path element comprises an operable refractive surface that is one of: a) a protruding surface, and b) an intruding surface.

24. The position measuring device of Claim 19, wherein each optical path element comprises one of: a) a relatively long and narrow ridge-like element having a prismatic cross section, and b) a diffractive optical element that deflects light rays approximately like a relatively long and narrow ridge-like element having a prismatic cross section.

25. The position measuring device of Claim 24, wherein the target member comprises a plurality of respective unique patterns usable to uniquely identify respective regions of the target member.

26. A position measuring device usable for measuring a relative position between the position measuring device and a target member, the position measuring device comprising:

an array detector;

an optical path array element comprising a plurality of optical path elements, the optical path array element positionable to input image light from the target member; and

an angular filter portion having an optical axis, the angular filter portion positioned to receive output image light from the optical path array element and having

direction-selecting characteristics such that it is operable to transmit only direction-selected light rays of the output image light to form an image corresponding to at least a portion of the target member on the array detector,

wherein:

the target member includes at least one respective target feature;

the image corresponding to at least a portion of the target member on the array detector includes at least one respective image feature corresponding to a respective target feature;

each respective image feature corresponding to a respective target feature is defined by a set of light rays of the input image light that enter a respective set of optical path elements that are effectively direction-selected relative to the respective target feature, based at least partly on the direction-selecting characteristics of the angular filter portion; and

for at least one respective target feature at least one of a size and a position of the corresponding respective image feature on the array detector is usable to determine at least one measurement value for the respective target feature, the at least one measurement value corresponding to at least one translational degree of freedom of the position measuring device position relative to the at least one respective target feature.

27. The position measuring device of Claim 26, wherein the at least one respective target feature comprises at least three respective target features, the at least one measurement value comprises three measurement values corresponding to three translational degrees of freedom of the position measuring device position relative to each of the at least three respective target features, and the position measuring device is usable for measuring a 6- degree-of-freedom relative position between the position measuring device and the target member.